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EVALUATION OF CATHODE-RAY TUBE PROTECTION FOR THE ELECTRONIC TA--ETC(U)
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EVALUATION OF CATHODE-RAY TUBE PROTECTION FOR THE ELECTRONIC TABULAR DISPLAY SUBSYSTEM (ETABS) ENGINEERING MODEL

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16. Abstract

This report describes the safety evaluation of the 25-inch (diagonal) rectangular cathode-ray tube (CRT) that is used in the engineering model of the Electronic Tabular Display Subsystem (ETABS). An evaluation of ETABS will be performed at the Federal Aviation Administration (FAA) Technical Center for possible application in FAA Air Route Traffic Control Centers (ARTCC).

The safety evaluation included standard industry pressure testing and special implosion testing on 12 CRT samples. Eleven of the twelve CRT samples satisfactorily met the safety requirements for both the pressure and implosion testing. One CRT cracked when subjected to 45 pounds per square inch (psi) of air pressure; however, the CRT did not implode. The 25-inch rectangular CRT will therefore provide a high degree of safety for use in each of the two tabular displays of the ETABS engineering model.

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METRIC CONVERSION FACTORS

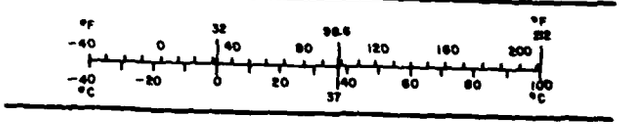
Approximate Conversions to Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
in	inches	*2.5	centimeters	cm
ft	feet	30	centimeters	cm
yd	yards	0.9	meters	m
mi	miles	1.6	kilometers	km
	AREA			
in^2	square inches	6.5	square centimeters	cm^2
ft^2	square feet	0.09	square meters	m^2
yd^2	square yards	0.8	square meters	m^2
mi^2	square miles	2.6	square kilometers	km^2
	acres	0.4	hectares	ha
	MASS (weight)			
oz	ounces	28	grams	g
lb	pounds	0.45	kilograms	kg
	short tons (2000 lb)	0.9	tonnes	t
	VOLUME			
tsp	teaspoons	5	milliliters	ml
Tbsp	tablespoons	15	milliliters	ml
fl oz	fluid ounces	30	milliliters	ml
c	cups	0.24	liters	l
pt	pints	0.47	liters	l
qt	quarts	0.95	liters	l
gal	gallons	3.8	liters	l
ft^3	cubic feet	0.03	cubic meters	m^3
yd^3	cubic yards	0.76	cubic meters	m^3
	TEMPERATURE (exact)			
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

*1 in = 2.54 (exactly). For other exact conversions and more detailed tables, see NBS Misc. Publ. 286, Units of Weights and Measures, Price $2.25, SD Catalog No. C13.10:286.

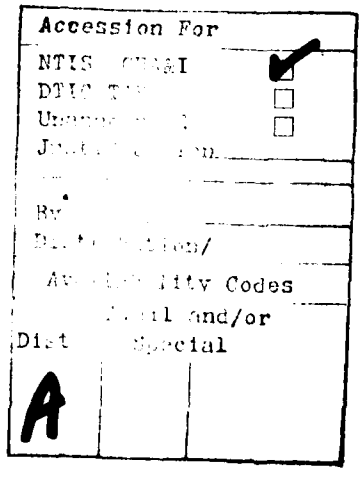
Approximate Conversions from Metric Measures

Symbol	When You Know	Multiply by	To Find	Symbol
	LENGTH			
mm	millimeters	0.04	inches	in
cm	centimeters	0.4	inches	in
m	meters	3.3	feet	ft
m	meters	1.1	yards	yd
km	kilometers	0.6	miles	mi
	AREA			
cm^2	square centimeters	0.16	square inches	in^2
m^2	square meters	1.2	square yards	yd^2
km^2	square kilometers	0.4	square miles	mi^2
ha	hectares (10,000 m^2)	2.5	acres	
	MASS (weight)			
g	grams	0.035	ounces	oz
kg	kilograms	2.2	pounds	lb
t	tonnes (1000 kg)	1.1	short tons	
	VOLUME			
ml	milliliters	0.03	fluid ounces	fl oz
l	liters	2.1	pints	pt
l	liters	1.06	quarts	qt
l	liters	0.26	gallons	gal
m^3	cubic meters	35	cubic feet	ft^3
m^3	cubic meters	1.3	cubic yards	yd^3
	TEMPERATURE (exact)			
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



PREFACE

Grateful appreciation is conveyed to Lydia Mitchell and Gary Slobodin, engineering cooperative students of the Systems Integration Branch, for their timely and extensive assistance in performing the safety testing.



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INTRODUCTION

PURPOSE.

The purpose of this project was to conduct safety tests to evaluate the 25-inch (diagonal) rectangular cathode-ray tube (CRT) with a Kimcode™ rimband device and protective glass panel for its safe use in the Electronic Tabular Display Subsystem (ETABS) engineering model and in possible future Air Route Traffic Control Center (ARTCC) implementation.

BACKGROUND.

In 1973, a 23-inch CRT imploded violently in a Plan View Display (PVD) at the Cleveland ARTCC (Oberlin, Ohio). The display was being used at the time by an air traffic control specialist (ATCS) to control air traffic. He was not injured, although small glass fragments were scattered around the PVD for a distance of 6 feet. Following this, the Federal Aviation Administration (FAA) Technical Center was asked to investigate the cause of the CRT implosion and how the CRT could be modified to retain any flying glass fragments in the case of a violent implosion.

The Technical Center investigated the feasibility of employing a Kimcode-type implosion protection system. The Kimcode system consists of a four-piece steel shell which is fastened to the critical shoulder area of the CRT to counteract the forces that cause an implosion. The Kimcode system is a development of Owens-Illinois, Incorporation, and is registered under United States patent numbers 3,220,592 and 3,220,593. Extensive safety testing was conducted by the FAA Technical Center on the 23-inch CRT with the Kimcode protective banding. It was concluded that the 23-inch CRT, incorporated with the Kimcode implosion protection system, could not be imploded. (See references 1 through 3.)

The FAA Technical Center will be evaluating the ETABS engineering model for possible application in FAA ARTCC's. ETABS would replace the paper flight strips currently used by the air traffic controller to list pertinent data of the flights under control. The ETABS console is equipped with two 25-inch (diagonal) rectangular CRT's (see figure 1). The 25-inch rectangular CRT incorporates the same Kimcode rimband device and protective glass panel that the 23-inch CRT incorporates. It was determined that the FAA Technical Center would perform a safety evaluation on the 25-inch rectangular CRT similar to the evaluation conducted on the 23-inch CRT.

DISCUSSION

TEST CONFIGURATION.

The following elements of test apparatus were used in the safety evaluation:

1. Twelve 25-inch (diagonal) rectangular CRT's that incorporate the Kimcode rimband device and protective glass panel were used for the implosion and pressure testing. These CRT's were developed by the Raytheon Company (Quincy, Massachusetts) and utilized type No. 25V90 glass envelopes under Raytheon Tube No. 2607. Each CRT had holes, which were designated for penetration of a center punch, cut into three locations of the Kimcode rimband. The holes were located at the midpoint of the longer CRT side, at the corner of the longer CRT side, and at the midpoint of the shorter CRT side. A closeup view of the center punch penetrating the corner hole of the CRT is shown in figure 2.

2. The pressure tank apparatus is shown in figure 3. The CRT was inserted in a wire basket and then lowered into the pressure chamber. An air compressor was used to pressurize the chamber after the lid was bolted shut.

3. A test setup for the 25-inch CRT is shown in figure 4. This test setup was specifically designed for the 25-inch CRT, whereas a modified PVD was previously used for the implosion testing of the 23-inch CRT. The CRT was bolted to the four corners of the test setup.

4. The implosion room (see figure 5) houses the test setup previously described. A hole was cut through the implosion room door for insertion of the hammering rod and center punch used to penetrate the CRT. (See figure 6.)

TEST PROCEDURE.

Twelve 25-inch rectangular CRT's with the Kimcode rimband and protective glass panel underwent military standard pressure testing. Upon successful completion of the pressure evaluation, the CRT's underwent implosion testing.

PRESSURE TESTING. The following method is used for pressure testing: Each CRT is placed in the pressure tank apparatus, and the lid is bolted shut. The pressure gauge reading should be zero pounds per square inch (psi) indicating that the pressure chamber has the normal atmospheric pressure of approximately 15 psi. Pressure is slowly added at a rate of 1 psi for every 1-second time interval. At the end of 30 seconds, the pressure gauge should read 30 psi. This indicates that there is a total of 45 psi inside the pressure chamber. At this point, no more pressure is added. The 45 psi inside the pressure chamber is maintained for 60 seconds. At the end of 60 seconds, the pressure inside the chamber is quickly released to the atmosphere. The CRT is then removed from the chamber and inspected. If there is no physical damage to the tube, then the CRT has passed the acceptance criteria for pressure testing. (See reference 4.)

IMPLOSION TESTING. The following method is used for implosion testing: Each CRT is secured in the implosion apparatus. The implosion apparatus is then positioned in the implosion room so that the hole location of the CRT is accessible to the implosion room door. The steel rod and sharpened center punch are inserted through the upper hole in the implosion room door and aligned with the hole location of the CRT. (For this evaluation, the first set of tests involved four CRT's using the corner hole location of the longer CRT side; the second set of tests involved four CRT's using the middle hole location of the longer CRT side; and the last set of tests involved three CRT's, using the middle hole of the shorter CRT side.) After the CRT has been properly set up, coolant is sprayed for 45 seconds on the critical glass area of the CRT through the hole location of the Kimcode rimband. The critical glass area is the location on the CRT shoulder which is most susceptible to mechanical stress leading to implosion. The purpose of using coolant is to induce stresses in the critical glass area and thus make it vulnerable to penetration upon impact by the center punch. At the end of 45 seconds, the coolant spray is stopped and the steel rod and center punch are hammered into the critical area of the CRT (see figure 6). The rod is hammered until the center punch penetrates through the glass and causes the tube to crack and lose vacuum or to violently implode. If no glass is expelled from the tube and the protective glass panel does not break, the CRT passes this test even though the faceplate of the CRT bottle may crack.

TEST RESULTS.

Eleven of the twelve CRT's pressure tested had no physical damage and therefore passed the acceptance criteria. The twelfth CRT did not pass the acceptance criteria because a crack

developed on the side wall of the CRT bulb. (See figure 7.) The engineer conducting the test heard an audible noise from the tank about 10 to 15 seconds after the pressure in the tank reached 45 psi. The pressure in the tank dropped about 1 psi at the time the noise was heard. The engineer increased the pressure back up to 45 psi in the tank until the 60-second holding time was complete. At the end of 60 seconds, the pressure in the tank was quickly released to the atmosphere. The CRT was carefully lifted out and forcibly filled with air for safety. This CRT was not implosion tested. As shown in figure 7, the crack seemed to terminate under the Kimcode rimband shell. Although this crack did occur, the CRT did not implode.

All 11 CRT's tested passed the implosion protection requirements. The integral faceplates of all the CRT's cracked, but the protective glass panels covering the faceplates had no physical damage. There was no apparent pattern to the way the faceplates cracked, except that most of the cracks and shattered glass were concentrated near the center punch penetration area of the CRT. There was also no difference in the pattern of faceplate cracks when using the different hole locations. A photograph of a CRT that was implosion tested is shown in figure 8.

The faceplate of the CRT bulb cracked where the center punch entered the bulb, but the protective glass panel had no physical damage. No glass was expelled from any of the CRT's tested.

CONCLUSIONS

The results of the safety testing show that the Kimcode rimband device and the protective glass panel are very effective in preventing violent imposions of the Electronic Tabular Display Subsystem (ETABS) 25-inch cathode-ray tube (CRT). It is concluded that the 25-inch rectangular CRT with these enhancements provides a high degree of safety for potential use in ETABS.

RECOMMENDATIONS

If the Electronic Tabular Display Subsystem (ETABS) is approved for field implementation, the Federal Aviation Administration (FAA) Technical Center recommends that the 25-inch (diagonal) rectangular cathode-ray tube (CRT), which is used in close proximity viewing, should be specified to include the Kimcode™ safety rimband device and protective glass panel.

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3. Report on Cathode-Ray Tubes Used in Equipment at Air Traffic Control Centers, Underwriters Laboratories, Inc., File USNC58, March 1975.

4. Test Methods for Electron Tubes, MIL-STD-1311, Method 1141, U.S. Department of Defense, Washington, D.C.

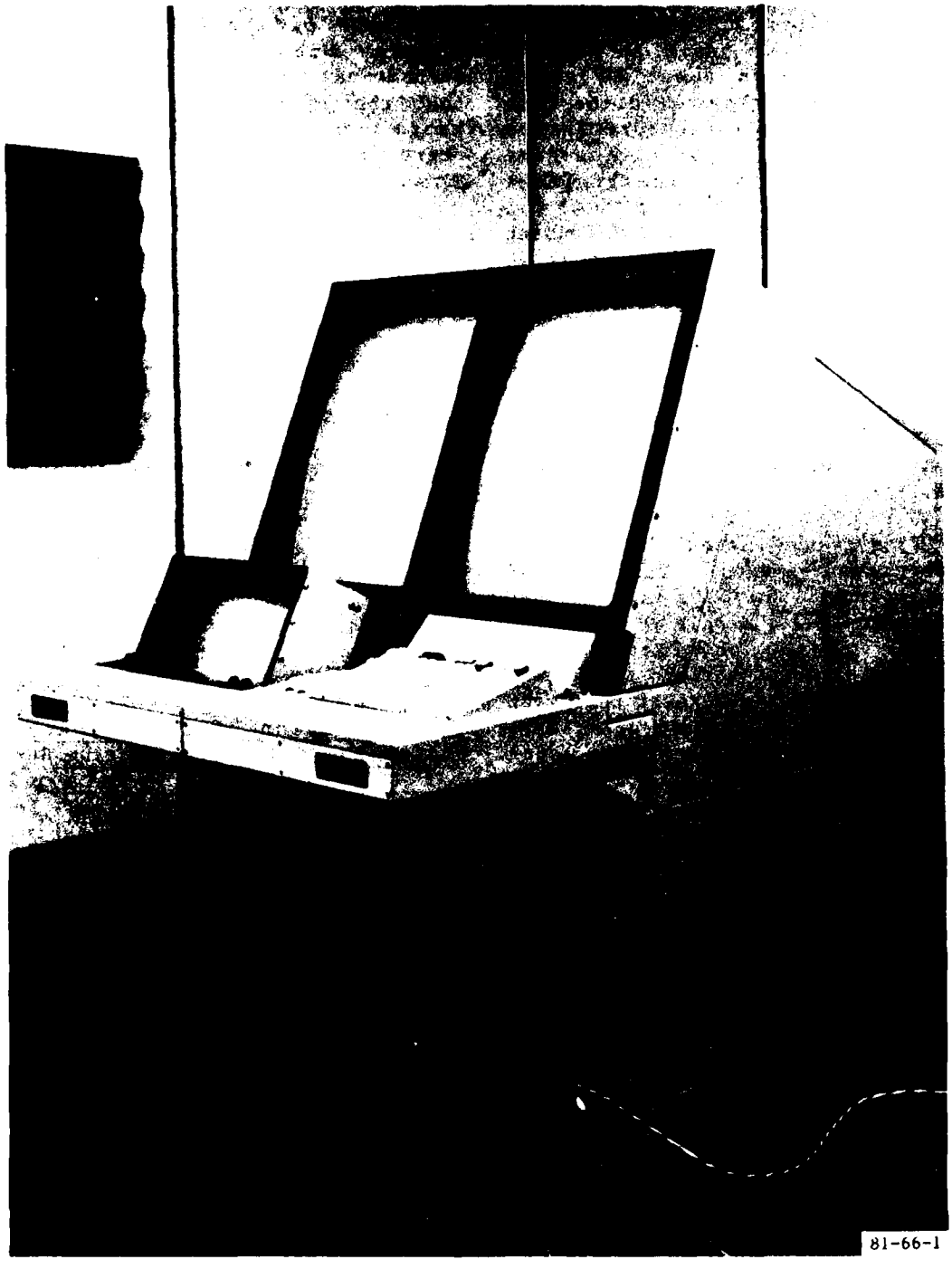

FIGURE 1. ETABS CONSOLE

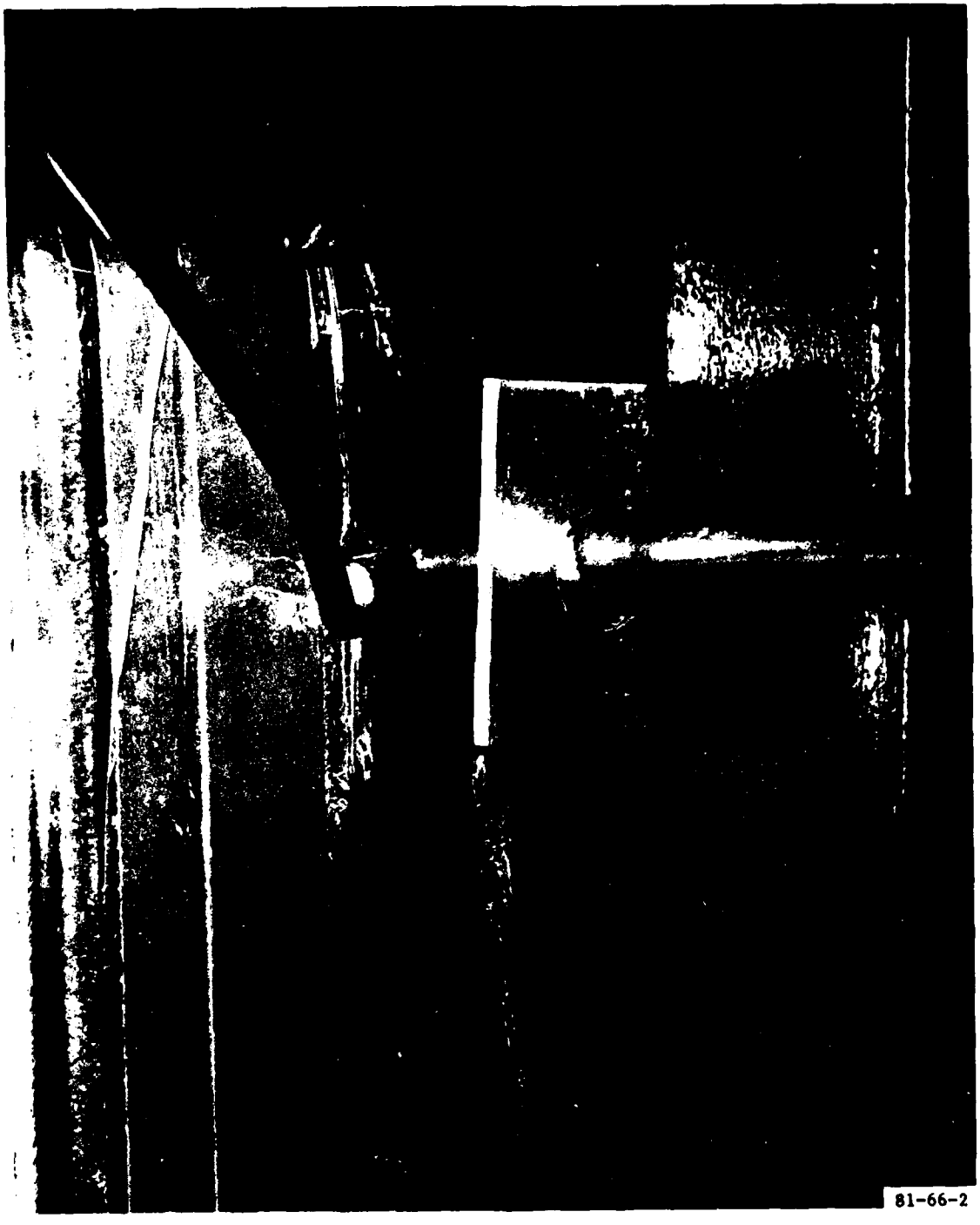

FIGURE 2. CLOSEUP OF IMPACT AREA SHOWING HOLE IN KIMCODE™ SAFETY RIMBAND, COOLANT TUBE, AND CENTER PUNCH

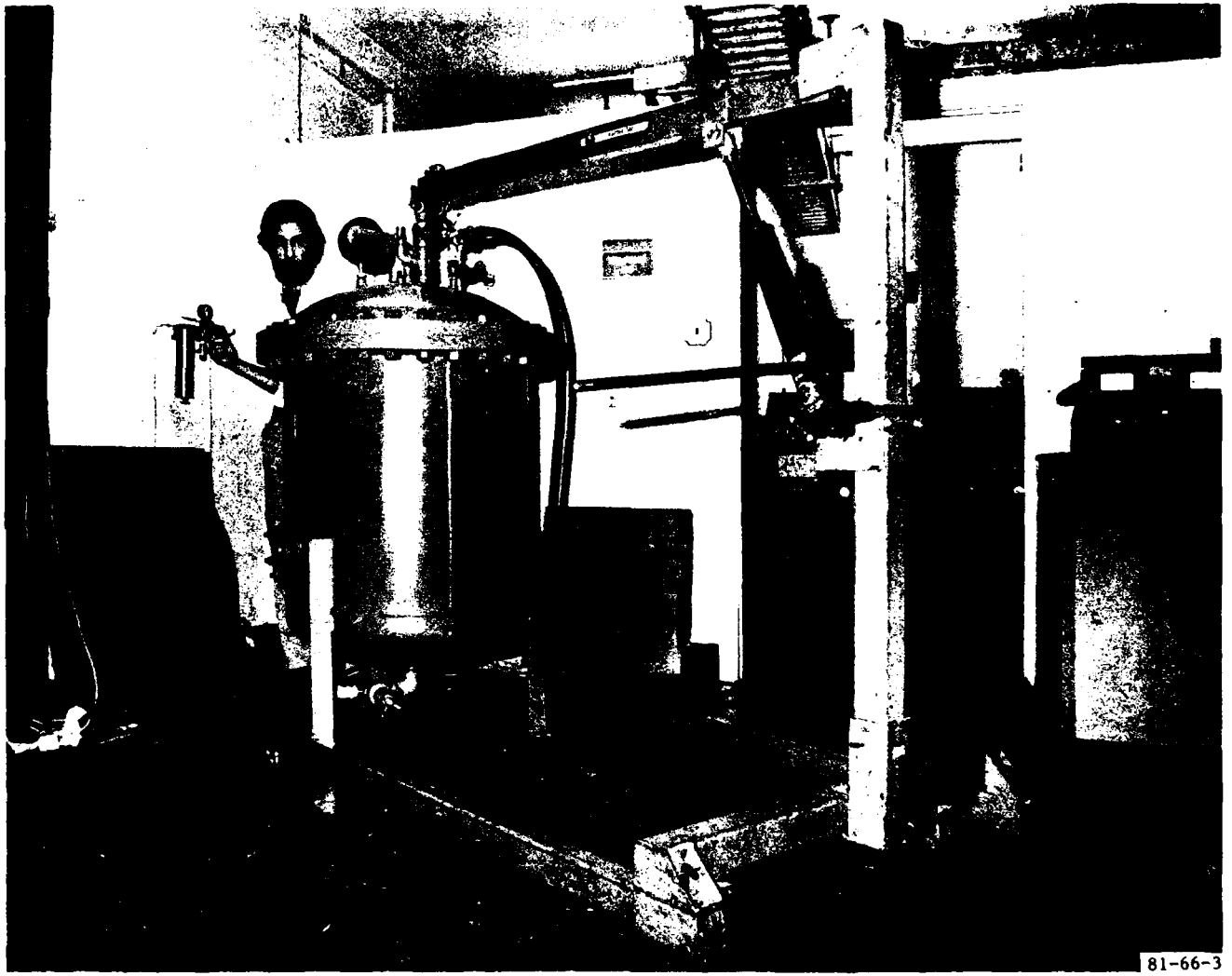

FIGURE 3. ENGINEER ADDS PRESSURE TO PRESSURE TANK

FIGURE 4. IMPLOSION TEST SETUP FOR 25-INCH RECTANGULAR CRT

FIGURE 5. IMPLOSION ROOM

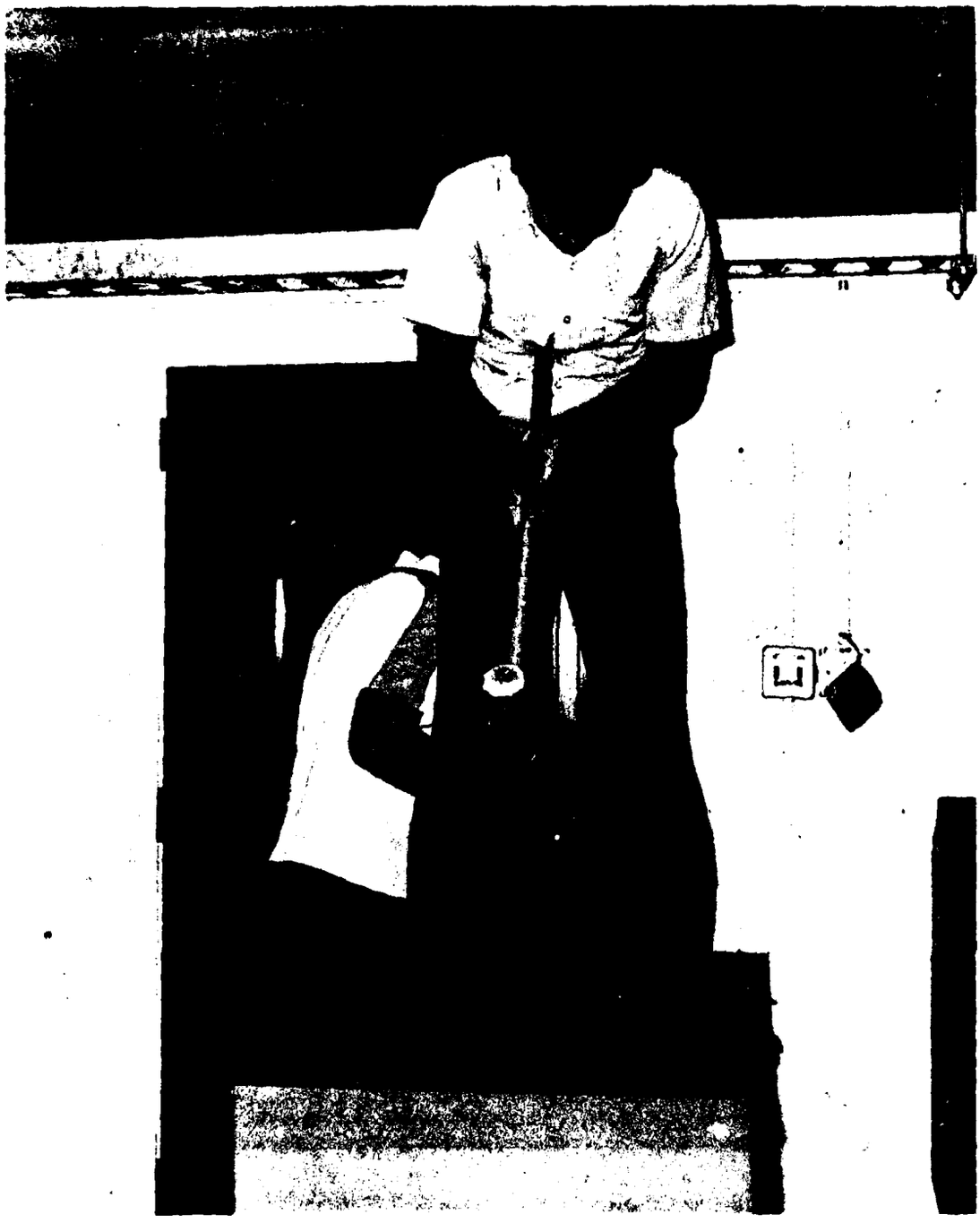

FIGURE 6. ENGINEER HAMMERS STEEL ROD THROUGH HOLE IN IMPLOSION ROOM DOOR

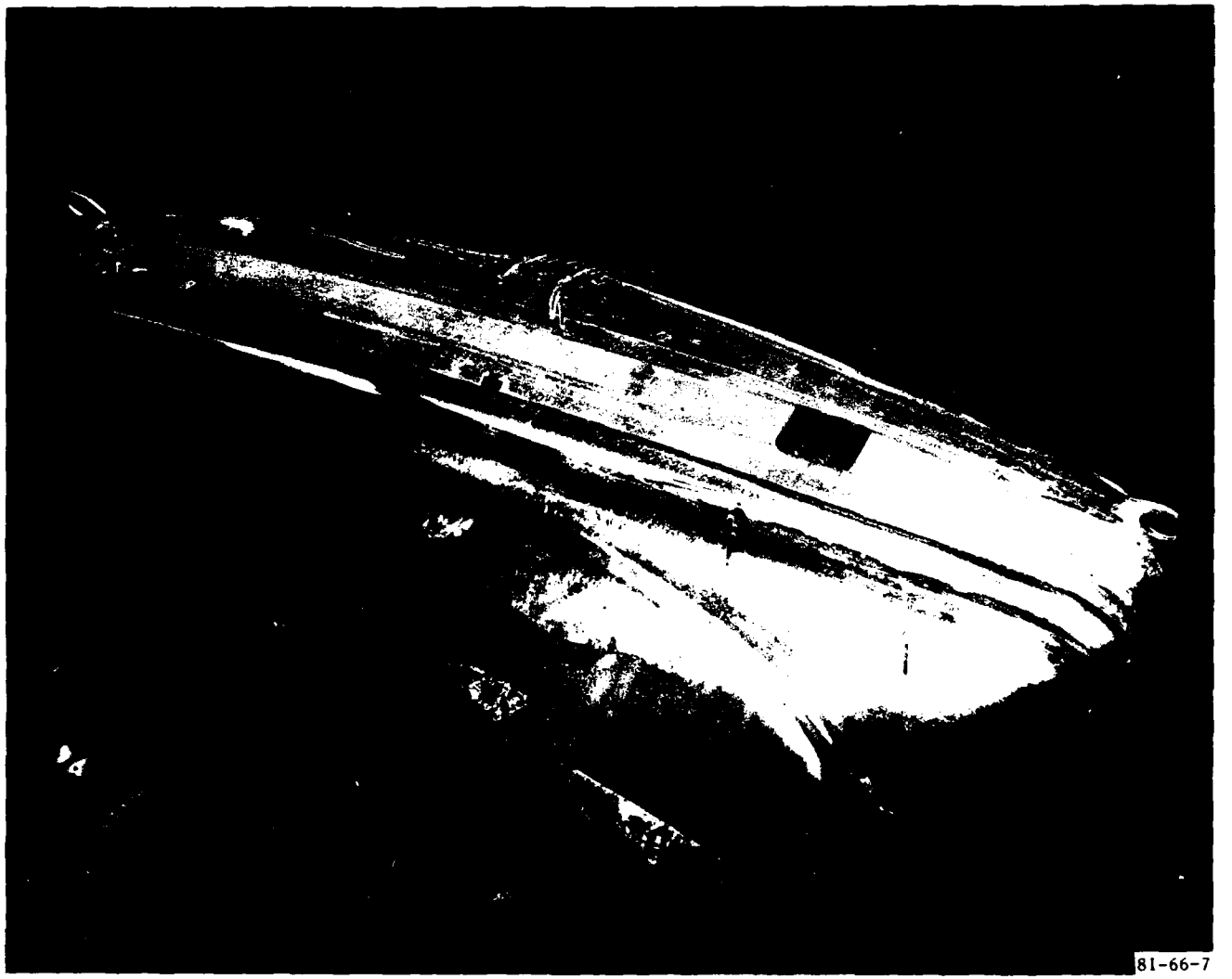

FIGURE 7. TWENTY-FIVE-INCH CRT THAT CRACKED DURING PRESSURE TESTING

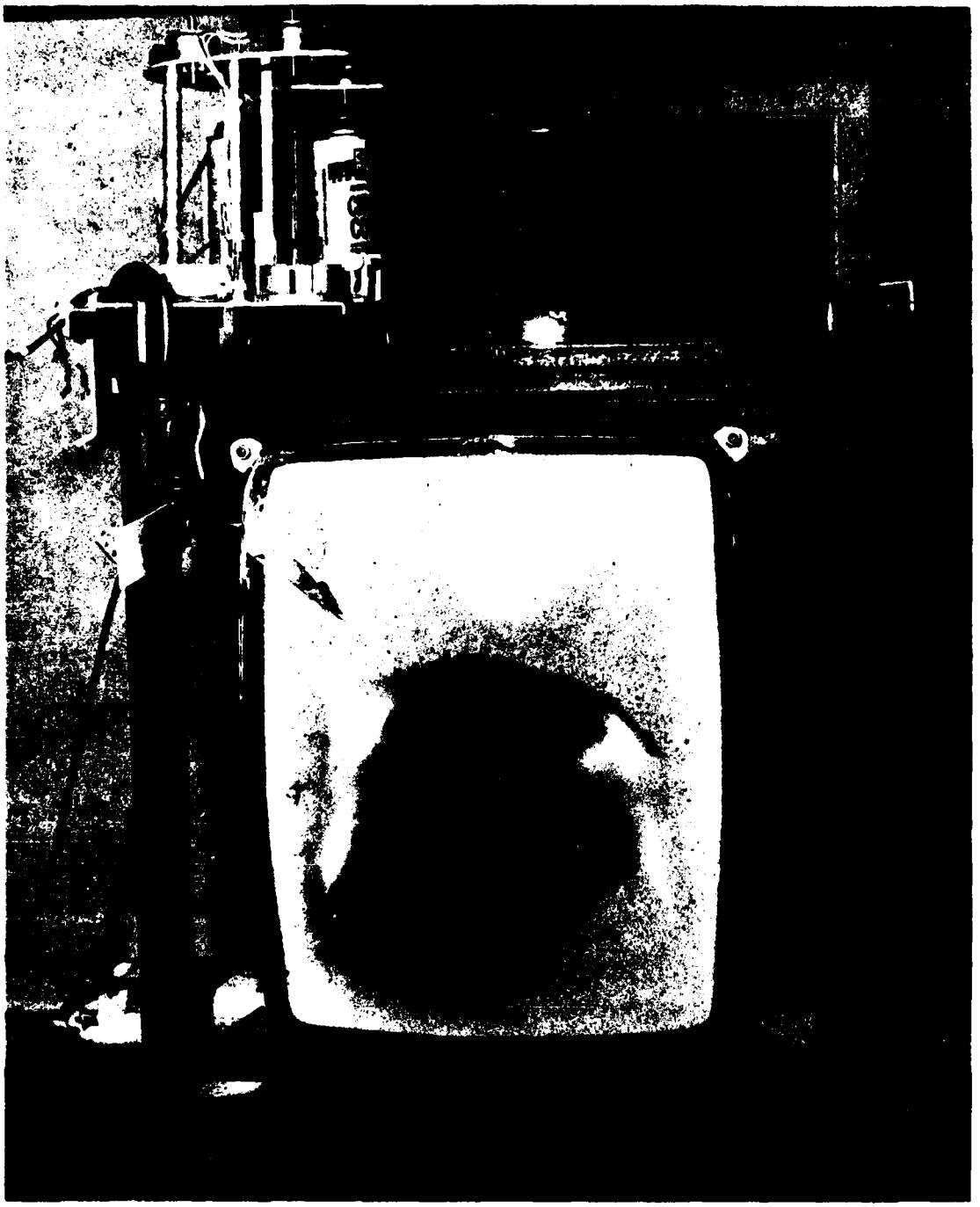

FIGURE 8. TWENTY-FIVE-INCH CRT AFTER BEING IMPLOSION TESTED


DATE
FILMED
0-8